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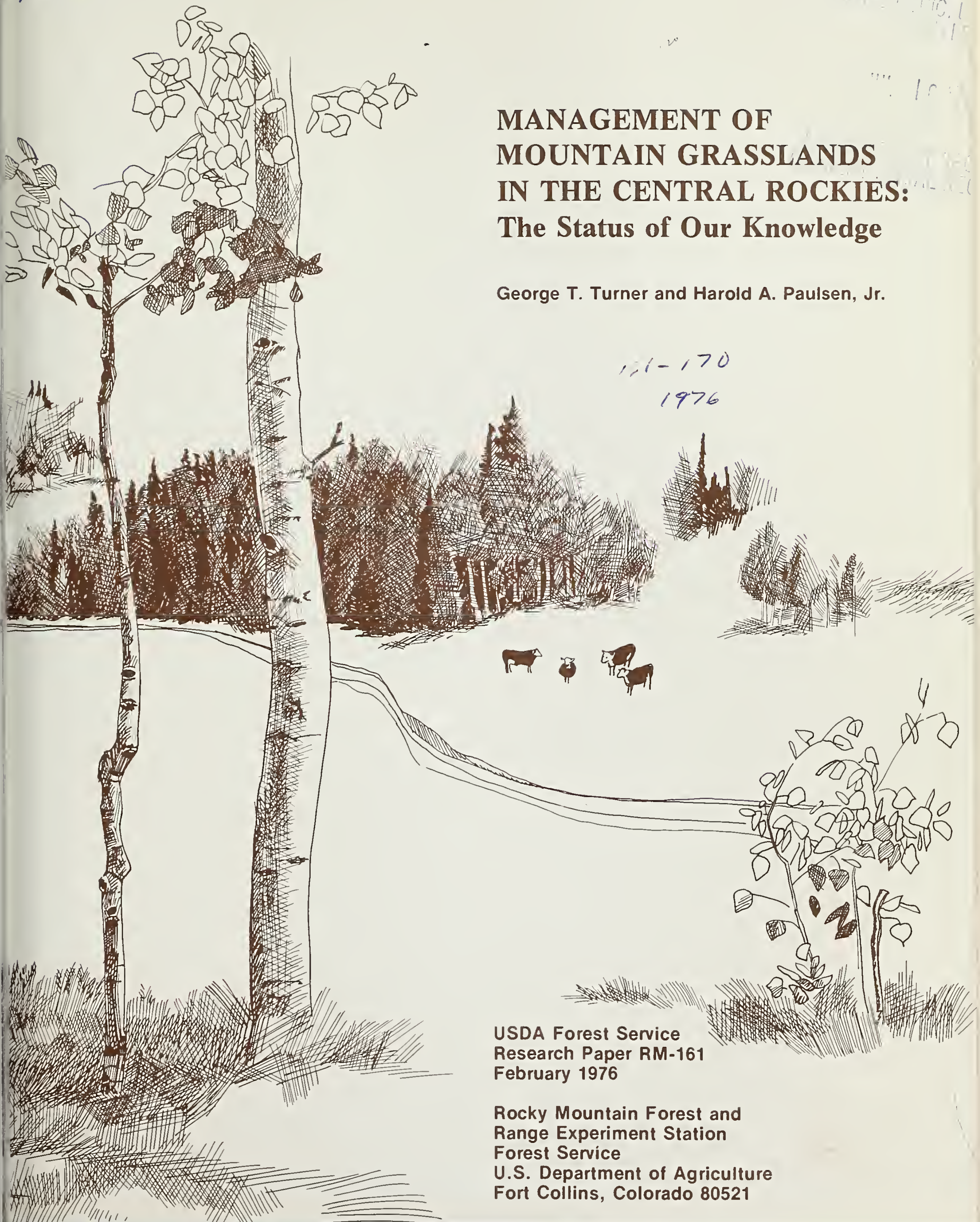

MANAGEMENT OF MOUNTAIN GRASSLANDS IN THE CENTRAL ROCKIES:
The Status of Our Knowledge

George T. Turner and Harold A. Paulsen, Jr.

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Abstract

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Mountain grasslands provide important summer grazing for livestock and big game. Knowledge is generally adequate for proper grazing management of these grasslands, but management and improvement costs tend to be relatively high because of their remoteness. Suggested improvements to increase range usability, improve forage production, and control livestock must be coordinated with water and timber production, and wildlife and recreation needs.

Keywords: Range management, mountain grasslands, subalpine forest ranges.

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The Status of Our Knowledge

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INTRODUCTION

Management of mountain grasslands, as with lower elevation ranges of western United States, has evolved since the early 1900's from concerns voiced as to depleted ranges, erosion, excessive livestock numbers, and lack of management. Pioneer range managers and range researchers initiated practices and installed studies to gain understanding of the resource, and curtail its widespread destruction. Since these early days, the basic principles and strategies of range management have developed that provide the contemporary land manager with necessary tools for wiser use of the resource. Many are commonplace technology to today's range manager, but they stem from far-reaching fundamental research, empirical studies, and years of experience.

This publication summarizes information from these sources. Its purpose is to provide a resumé of the published literature and accepted practices pertinent to the management of mountain grassland ranges of the central Rockies, and to identify gaps in existing knowledge that handicap the range manager in meeting his multiresource responsibilities.

Mountain grasslands of the central Rockies are closely associated with the subalpine forests in Wyoming, Colorado, New Mexico, and Arizona (fig. 1). The forest types commonly occur at elevations between 8,000 and 11,500 feet, or between the upper

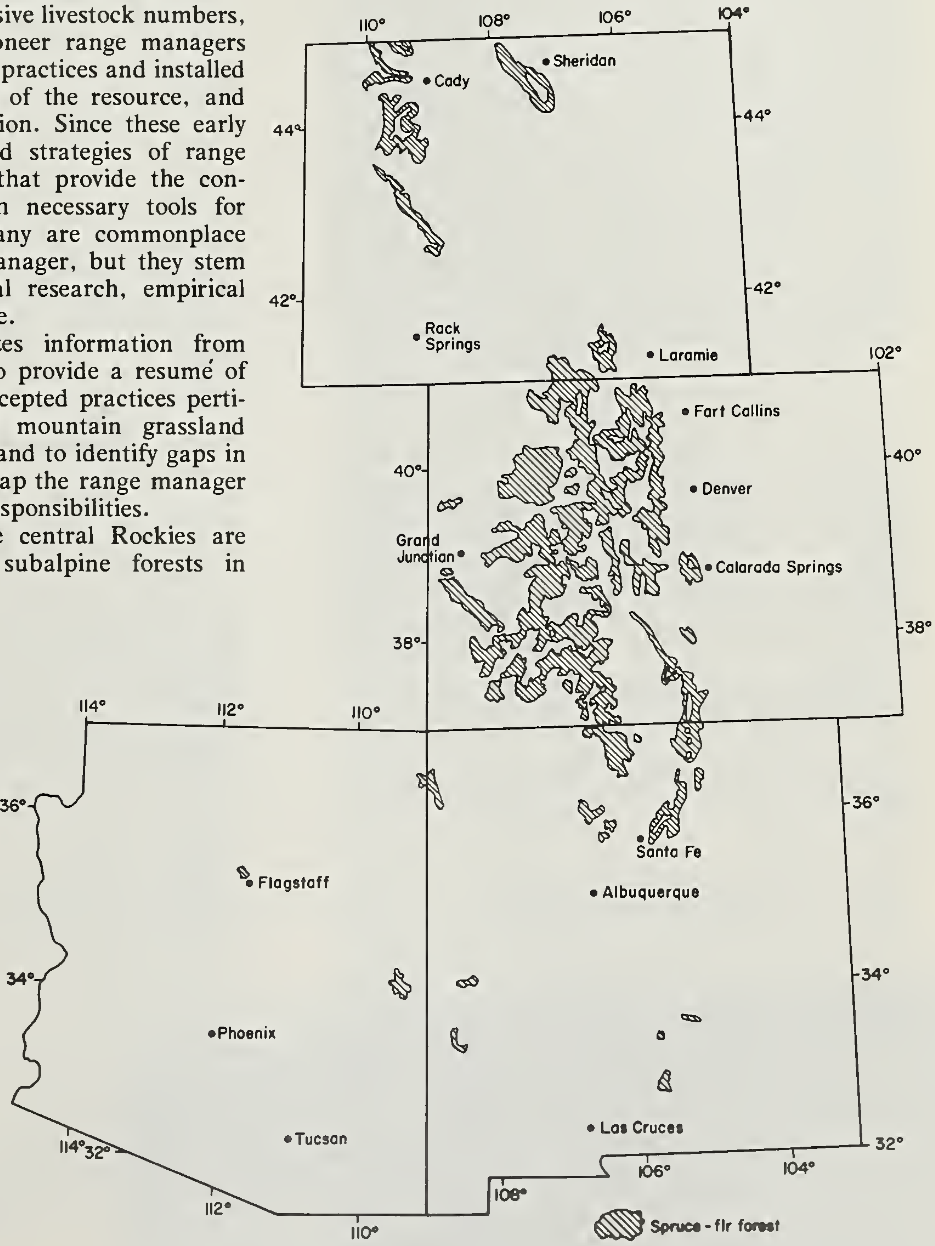

Figure 1.—Spruce-fir forests of the central Rockies within which are intermingled mountain grasslands.

limits of the ponderosa pine[2] forests and timberline. Within the timber stands, mountain grasslands are interspersed as parklike openings that vary in size from a few to several thousand acres (fig. 2). The grasslands may be found on gentle to steep slopes, wide valleys, and broad, rounded ridges. Commonly their distribution and major physical characteristics are described on the basis of the more extensive forest types.

The region offers a multiplicity of resource products as well as less tangible values that center around its outstanding recreation-related attributes. Increasing utilization of its timber, skyrocketing demand for ski facilities, growth of new homes and communities, and expansion of water storage and transfer systems have become prominent concerns for the land manager and planner. Moreover, the traditional uses such as livestock operations and mining continue to be important elements in local and regional economies.

The subalpine forests of the central Rockies include lodgepole pine, quaking aspen, and Engelmann spruce-subalpine fir types as mapped by Küchler (1964). Frequently referred to as spruce-fir forests, they occupy about 15 million acres in the four-State area, with approximately 72 percent in Colorado, 16 percent in Wyoming, 11 percent in New Mexico, and 1 percent in Arizona. Of this area, grasslands probably comprise about 1½ million acres.

The spruce-fir type in Wyoming occurs mainly in the northern portion—on the Big Horn, Absaroka, and Wind River Mountains. From the Medicine Bow mountains in southern Wyoming, it extends southward almost continuously along the Continental Divide and through western Colorado into northern New Mexico. Elsewhere in New Mexico and in Arizona, it is limited to relatively small, widely separated areas at high elevations. Because the subalpine zone is most extensive in Colorado, the discussion pertains primarily to mountain grasslands of that area.

Mountain grasslands in the central Rockies were first grazed by domestic livestock about 100 years ago. The region lacked transportation, was remote from population centers, and was occupied by various tribes of Indians, all of which affected early settlement. Following the discovery of gold and silver in the mid-1800's, Indians were moved to reservations, railroads were built to serve the region, and settlement proceeded rapidly.

Large numbers of cattle were brought in to graze the lower, more accessible ranges. Those ranges soon were overstocked, and the demand increased for forage at higher elevations. Bands of sheep were brought in somewhat later than cattle. Range wars broke out as stockmen fought to retain their "rights" to graze lands of the open, Federal domain. By 1900, practically all grazable land was being grazed, and much had already been overgrazed. Maximum use occurred about 1918 to meet wartime demands.

Regulation of grazing on the higher rangelands began with the establishment of National Forests in the early 1900's. Specific areas were allotted to individual ranchers or groups of ranchers, and permits were issued which allowed them to graze specific numbers and kinds of livestock for specified periods. Present use of National Forest rangeland in the West is only about 25 percent of what it was at one time. Much of the reduction has resulted from a decline in sheep numbers and shortening of the grazing season (USDA Forest Service, unpublished data).

[2]*Common and scientific names of plants and animals mentioned or found in the mountain grasslands are listed at the end of this paper.*

Figure 2.—Mountain grassland parks occur intermixed with high-elevation forests.

PHYSICAL ENVIRONMENT

Climate

The general climatic regime is typical of subalpine forests, and is broadly characterized by cold winters and relatively cool summers. Although far inland from the Pacific Ocean and the Gulf of Mexico, the higher elevations receive rather large amounts of precipitation in comparison to the adjacent valley lowlands. Winter storms that move inland from the Pacific lose much of their moisture before reaching the central Rockies; relatively more precipitation falls on the Western Slope than east of the Continental Divide.

Long winters, deep snow, and short growing seasons characterize the climate of mountain grasslands. Average annual precipitation varies from 20 to 40 inches. Snow accounts for 50 to 75 percent of the total. The ground frequently is snow covered from October until May, and the snowpack commonly attains a depth of 6 feet.

Winter temperatures often reach subzero levels, especially in January and February. However, surface soil temperatures under a deep snowpack are usually not much below 32°F. Under such conditions, some plants remain green throughout the winter, and others begin growth while the ground is still snow covered.

Snowmelt during a 2- or 3-week period in April or May usually saturates the soil mantle (fig. 3). Ample soil moisture and rapidly rising temperatures following snowmelt promote rapid plant growth.

Rainfall in June tends to be low west of the Continental Divide and relatively high east of the Divide. Thunderstorms in July and August are common throughout the region. Although monthly rainfall varies widely from year to year, total amounts from June through September range from about 6 to 10 inches.

Temperatures during summer months are cooler at the higher elevations and upper latitudes. At intermediate locations, the growing season usually extends from June through August. Even then, frost occurs occasionally. During July and August, temperatures average about 50° to 55°F; seldom do they exceed 75° or 80°F. Killing frosts, usually early in September, soon are followed by fall snowstorms.

Geology and Soils

Geology of the Rocky Mountains is extremely complex. The present Rockies were formed after older mountain ranges had been nearly leveled by erosion, leaving thick deposits of sediment. As upheaval was renewed, most of the overburden was again eroded away, but some remained as peneplains, fault blocks, remnants of folded structures, or irregular masses of metamorphic rock. As the Rockies continued to rise, underlying intrusive igneous rocks became widely exposed along the central axis, especially at the higher elevations. Much of the eroded material was redeposited to form the Colorado Plateau west of the mountain chain and the Great Plains along the eastern slopes.

Concurrent with and following uplift of the mountains, volcanic materials were extruded at scattered locations. Some deposits, such as those in southwestern Colorado and northwestern Wyoming, are deep and extensive; others occur locally in thin mantles. As a group, igneous materials underlie equally as much of the land surface as sedimentary rocks in the subalpine zone.

Landscape of the Rockies has been modifed more recently by glaciers and swift-flowing streams. In the upper part of the subalpine zone near timberline, alluvial deposits are common. At lower elevations, streams have cut a network of valleys and steep-walled canyons, especially in the plateaus of western Colorado. Valleys are sharply incised between mesas capped with erosion-resistant materials. Where soft shales are exposed, a hilly terrain has developed. Occasional landslides in those areas continue to alter the landscape.

Soils of the region are as variable as the parent materials from which they were derived and the conditions under which they developed. Cool to cold temperatures, relatively abundant moisture, and the dominant coniferous forest vegetation have favored the formation of podzolic soils on most high mountain areas. In the intermingled parks and open treeless slopes or ridges, grassland soils have developed. They generally resemble prairie soils in that the A-horizon is usually dark brown, relatively high in organic matter content, and slightly acid, with little, if any, lime accumulation. Although a clay pan is present in some areas, most mountain grassland soils are well drained. Fertility and productivity vary with soil parent materials, soil depth, and other factors of the local environment. Several soil series may be present within local areas (Retzer 1962, Smith 1969b). Much work is needed to identify, describe, and correlate characteristics of mountain grassland soils as a basis for determining land capabilities and making sound management decisions.

Vegetation

Mountain grassland vegetation is a continuum expressing many interacting factors of the local environment. Most grasslands support, or are capable of supporting, numerous kinds of perennial grasses and forbs. Annual plants seldom are abundant except on recently disturbed or severely overgrazed areas.

Two major but intergrading plant communities comprise the bulk of the mountain grassland type. Most extensive is the mountain bunchgrass community characterized by Thurber fescue, where that plant has not been eliminated by grazing. The range of Thurber fescue extends from southern Wyoming southward through Colorado into northern New Mexico. The Wyoming bunchgrass community occurs mainly in Wyoming, but fingers southward in northern Colorado. It is typified by Idaho fescue, which is

Figure 3.—Runoff during snowmelt on Black Mesa, western Colorado.

commonly associated with bluebunch wheatgrass and sagebrush (mainly big sagebrush) at lower elevations and on the drier sites (Williams 1963).

Other grasslands are found in the high-elevation, broad valley floors between major mountain ranges in central and southern Colorado. Species are often an admixture of elements from lower ranges with those of the higher and somewhat more mesophytic dry mountain meadows (Costello 1944).

On more moist sites, wet meadow communities occur throughout the major plant communities. Sedges dominate these areas, but tufted hairgrass, Kentucky bluegrass, and alpine timothy are frequently abundant together with a number of moisture-loving forbs.

Vegetation varies greatly. Conspicuous and distinct differences between plant communities frequently accompany marked changes in soil texture or exposure. Differences are less conspicuous with gradual changes in elevation or other features of the environment.

Mountain grasslands occupy sites where soils tend to be finer textured, deeper, and less well drained than on adjacent forested areas. Tree growth apparently is precluded from grassland areas because of competition from herbaceous plants, low temperatures, soil heaving, poor drainage, or other limiting factors. Where grasslands intermingle with timbered areas on hillsides, differences in site characteristics are usually less pronounced and trees are more likely to invade.

Under pristine conditions, Thurber fescue or Idaho fescue evidently comprised much of the vegetation, lending a grassland aspect to many high mountain parks. Forbs doubtless were locally abundant and conspicuous on recently disturbed sites. Within the subalpine zone, forbs tend to be more prominent at higher elevations and shrubs at lower elevations. A grassy understory commonly is overtopped by big sagebrush on relatively dry sites and by silver sagebrush on more mesic sites at upper elevations. Gambel oak and associated shrubs frequently comprise part of the plant cover on grasslands near the lower limit of the subalpine zone in Colorado.

Some of the other more common plants and their relative contribution to plant cover on relatively undisturbed grasslands are listed in table 1. Vegetative cover on the Colorado sites was described by Turner and Dortignac (1954) as "dense Thurber fescue." That in Wyoming was considered by Hurd (1961) to be representative of grasslands little used by livestock.

Several hundred plant species from mountain grasslands have been identified and described, including their general range and distribution (Coulter and Nelson 1909, Harrington 1954, Dayton 1960, Johnson 1964, Hermann 1966). However, local distribution, abundance, and ecologic relationships of many are not well known.

Table 1.--Plants commonly present on relatively undisturbed mountain grasslands in Colorado and Wyoming, and their relative contribution to vegetative cover

Colorado sites (4)		Wyoming sites (9)	
Species	Percent	Species	Percent
GRASSES AND SEDGES:		GRASSES AND SEDGES:	
Brome, mountain	2	Brome, pumpelly	4
Fescue, Idaho	5	Bluegrass, Sandberg	3
Fescue, Thurber	46	Fescue, Idaho	25
Needlegrass	2	Junegrass, prairie	3
Sedges	1	Needlegrass, subalpine	4
Wheatgrass, slender	1	Sedge, needleleaf	8
Other grasses	1	Spikefescue	3
Total	58	Wheatgrass, slender	3
		Wheatgrass, thickspike	2
FORBS:		Other grasses and sedges	8
		Total	63
Agoseris, pale	4		
Cinquefoil	2	FORBS:	
Dandelion, common	3		
Fleabane, aspen	6	Agoseris, pale	4
Geranium, Fremont	7	Avens	4
Peavine, aspen	3	Bedstraw, northern	2
Sneezeweed, orange	4	Lupine, silky	6
Yarrow, western	5	Yarrow, western	2
Other forbs	7	Other forbs	17
Total	41	Total	35
Other plants	1	Other plants	2
Total	100	Total	100

Common Fauna

Mountain grasslands are rich in fauna, the number of genera and species being proportional to the number of habitats (Hall and Kelson 1959). Because local climate, soils, and vegetation associated with grasslands and adjacent forests are diversified, various habitats characterize the subalpine zone.

Of the larger animals, mule deer are most abundant. They range throughout the type during the snow-free period. Elk are locally common, and at upper elevations may utilize grasslands more intensively than deer. Pronghorns occur in small bands in some of the large mountain parklands, and moose browse in wet meadows and along stream bottoms in Wyoming. Bighorn sheep, black bears, and mountain lions make casual use of grasslands.

Various birds, rodents, and other small mammals may be relatively important because of their wide distribution, occasional abundance, and influence on mountain grasslands.

Reptiles are scarce on mountain grasslands, the principal one being the garter snake (Yocum and others 1969). Salamanders, toads, and frogs are somewhat more common.

Plant Development

Most herbaceous plants begin growth in spring soon after snow disappears. The leaves of some, such as elk sedge, Gabriel's trumpet, and rock jasmine, remain green throughout the winter. Thurber fescue

produces new but chlorotic leaves while still under the snowpack. As temperatures rise following snowmelt, plant growth accelerates. However, some species develop faster than others, and the floral display changes continually during late spring and summer.

Early-blooming plants include fawn lily, spring beauty, greenleaf bluebell, and low larkspur. These plants mature and generally disappear by early summer. Mutton bluegrass is one of the earlier maturing grasses.

Typical of plants that bloom 6 to 8 weeks after snowmelt are mountain brome, Idaho fescue, western yarrow, orange sneezeweed, Fremont geranium, and Gabriel's trumpet. Species that bloom later include hairy goldaster, agoseris, and Parry rabbitbrush.

Plant development varies from year to year as well as with the microclimate of local sites (fig. 4). At high elevations, growth begins later but stages of development tend to be shorter than at low elevations; plants thus complete their life cycle in a relatively short period (Costello and Price 1939, Pond and Smith 1971). Temperature and moisture during the growing season, of course, influence the rate of development.

Range readiness also varies considerably, since development of the forage crop to a stage suitable for grazing depends on when the snow disappears and ensuing temperatures (Costello and Price 1939). According to guidelines of the USDA Forest Service (1962), most ranges are ready for grazing between mid-June and mid-July. However, when the snowpack is unusually deep and slow in melting, the grazing period may begin even later.

Floral aspects of mountain grasslands differ markedly from one year to another. Production of viable seed by individual plant species probably varies even more. For example, culms of Idaho fescue were produced in abundance only twice during a 5-year period in Wyoming (Pond and Smith 1971). Erratic production of seedstalks also has been observed on Black Mesa in Colorado over an 18-year period. Even though collected during two relatively good "seed years," seed of Idaho fescue germinated at an average rate of less than 10 percent. The inconsistency of grass seed production often has not been fully recognized in the development of grazing systems intended to provide for natural seeding of important range grasses.

Herbage Production

Herbage production on mountain grasslands occasionally exceeds 3,000 pounds per acre; however, yields of 1,000 to 2,000 pounds are much more common (Turner and Dortignac 1954, Hurd 1961). Above-average yields are produced on deep, fertile soils at intermediate elevations during years of favorable growing conditions. Highly productive sites may support a relatively dense cover of bunchgrasses, although some produce large yields of tall forbs (fig. 5). A variable mixture of grass and forb herbage is characteristic of mountain grasslands. Browse (mainly sagebrush or rabbitbrush) may be locally abundant.

Herbage production and composition vary considerably from year to year. During an 11-year period in which production on moderately grazed pastures in western Colorado averaged 1,456 pounds per acre (Paulsen 1969), yields ranged from 23 percent above to 27 percent below average. During that period, grasses contributed as little as 35 percent and as much as 62 percent to the total herbage. Although such variability is readily apparent, the underlying causes are obscure.

Peak development (maximum standing crop) of herbage is reached between mid-July and mid-August, after which weight of the biomass declines. If rainfall is adequate and well distributed, Kentucky bluegrass remains green throughout the summer and produces considerable regrowth after being grazed. Idaho fescue and other bunchgrasses produce little regrowth if grazed when past the vegetative stage (Pond and Smith 1971).

Plant Succession

Successional stages of mountain grassland vegetation are similar to other grasslands, except for kinds of plants present. With misuse, the more palatable plant species are replaced by less palatable ones better adapted to the altered environment; desirable perennial plants may be eliminated from the plant cover. These "stages" correspond in general to those described by Sampson (1923) as (1) climax herbaceous; (2) mixed grass and weed; (3) second or late weed; and (4) first or early weed stage.

In reality, plant successional stages are indistinct and variable. Floristic composition varies with site characteristics, forage preference and use by grazing animals, and other environmental influences. Because the factors that influence floristic composition and plant succession are complex, changes in prominence of individual plant species seldom can be interpreted with certainty on the basis of present knowledge. In general, however, nonpalatable forbs or shrubs tend to replace palatable grasses on mountain grasslands grazed by cattle, and grasses tend to replace the more palatable forbs on ranges grazed by sheep.

Because of the competitive advantage that nonpalatable or less preferred plants have on grazed range, discontinuance of grazing may serve only to retard or prevent further range deterioration; it may not shift competitive advantage to palatable plants. Consequently, well established, deep-rooted plants (such as Parry rabbitbrush) that are unpalatable and

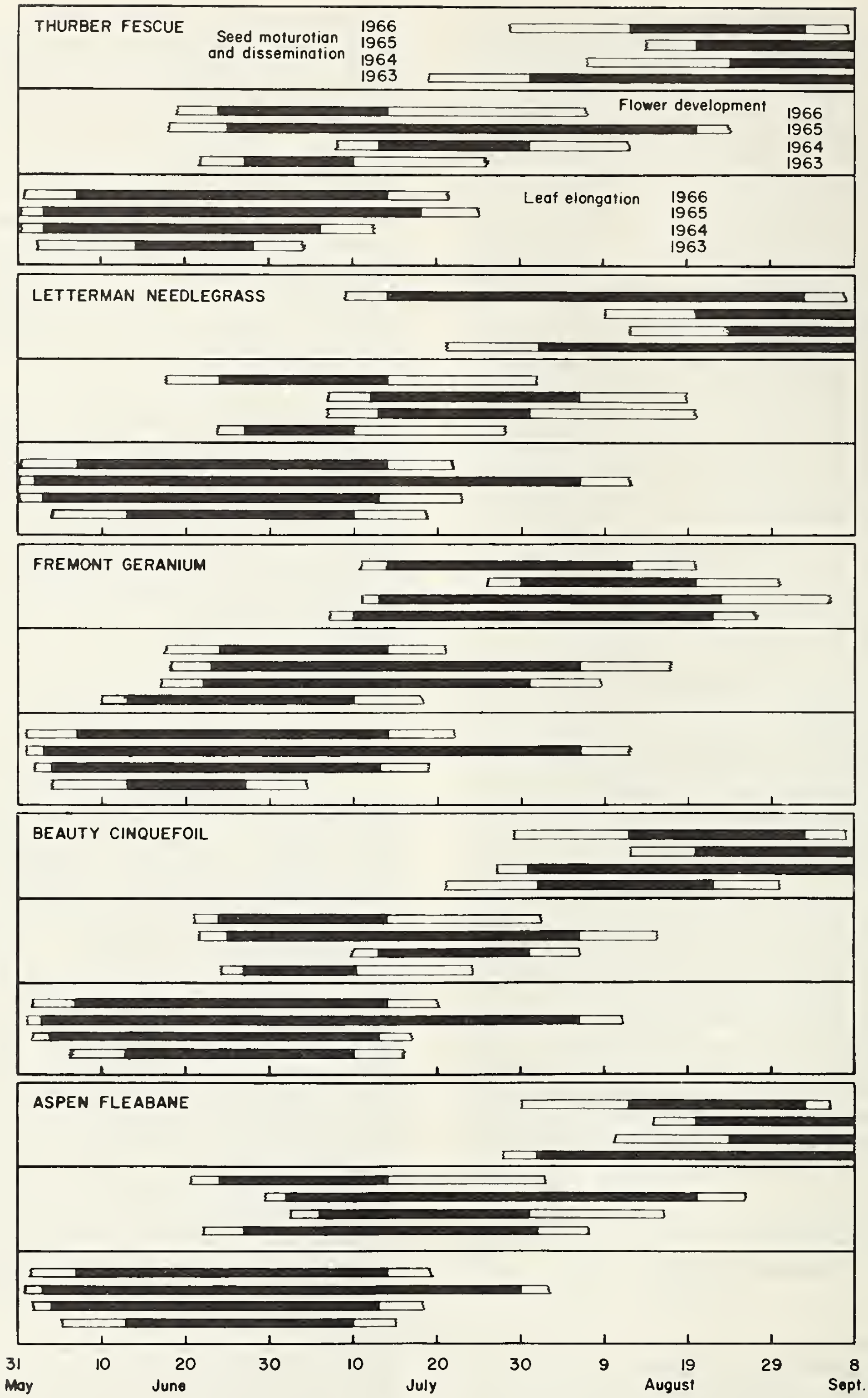

Figure 4.—Periods of leaf elongation, flower development, and seed maturation and dispersal of five species on Black Mesa, western Colorado. Open and irregular ends of the bars indicate dates for initiation and cessation of a phenological stage were indefinite (from Paulsen 1970b).

Figure 5.—Thurber fescue-forb cover, Black Mesa Experimental Range, western Colorado (from Paulsen 1970b).

locally abundant on Thurber fescue grassland may persist for years, regardless of grazing management.

On Black Mesa in western Colorado, plant cover on an area of Thurber fescue grassland protected from grazing for 8 years (Paulsen 1970b) remained generally unchanged: the grass-forb composition in 1962 was 62 percent grass versus 38 percent forbs; in 1969, 65 percent grass versus 35 percent forbs. Idaho fescue and Letterman needlegrass have remained prominent on Black Mesa under moderate grazing and occasional heavy use, but Thurber fescue has declined. The success of Thurber fescue on the experimental plots on Black Mesa (Paulsen 1970b) was attributed to its early and vigorous growth habit, abundant seed production, and successful seedling establishment. This species rapidly dominated the plots where forbs were removed from the plant cover.

Range deterioration is often characterized by changes in addition to the relative prominence of individual plant species. In early stages on cattle ranges, forbs or secondary grasses usually increase as primary grasses decrease. Total cover may change very little, and occasionally may increase. Herbage production and litter may decrease slightly; bare soil tends to increase. In more advanced stages of deterioration, reductions in ground cover and herbage yields become pronounced (Turner and Dortignac 1954, Klemmedson 1956). The aspect changes to that of forbs or shrubs, bare soil usually is conspicuous, and signs of runoff and erosion may become evident. With reduction in cover, the seedbed becomes more favorable for reproduction of certain plant species and less favorable for others.

Less evident, but equally important, are changes in the microenvironment and site characteristics that accompany range deterioration. With less ground cover (live and dead material), surface soil temperatures rise faster in the spring and continue higher throughout the summer. Although initial growth of plants may be accelerated, soil moisture is depleted through evaporation and contributes less to plant growth. Soil organic matter likely will be oxidized more readily (Albrecht 1938), affecting kinds, abundance, and activity of soil organisms. Eventually, soil fertility and productivity are reduced.

Pocket gophers and other small animals also influence floristic composition and the microenvironment. On Grand Mesa in western Colorado, available herbage was reduced by 20 percent or more where gophers numbered 25 to 30 per acre (Turner 1969). They may substantially reduce ground cover and may be the primary cause for the exposure of bare soil (Ellison 1946, Turner and others 1973). Gopher effects on infiltration, runoff, soil erosion, and moisture content of the soil vary with local conditions. On many areas their burrowing activity has resulted in mixing of soil horizons, and much vegetation has been covered by the soil they excavated (Ward and Keith 1962). Other studies of mountain grassland and aspen communities, however, have indicated gophers performed a useful function through cultivating and aerating the soil without reducing total herbage production (Ellison and Aldous 1952).

Control of pocket gophers may result in increased abundance of certain animals and decreased abundance of others. With thinning of ground cover, the habitat may become more suitable for deer mice but less favorable for montane voles (Larrison 1942, Tester and Marshall 1961). Activities of these and other small animals, including birds and insects, may markedly influence the amount, kind, and disposition of plant seed.

Often, however, responses caused by rodent activities cannot readily be distinguished from effects of livestock grazing and weather. Influences of fire, soil erosion, phytotoxins (allelochemicals), and soil nutrients also complicate understanding of the composition and succession of mountain grassland vegetation (Ellison 1949, Miller 1963, U.S. Natl. Comm. Int. Biol. Program 1971, Wright 1971).

On Colorado ranges that are grazed too heavily by cattle, Thurber fescue commonly is replaced by Idaho fescue and associated bunchgrasses on relatively coarse-textured soils, and by Kentucky bluegrass on fine-textured or compacted soils. Western wheatgrass and mulesear sometimes occur on fine-textured soils along with or instead of Kentucky bluegrass (Turner and Dortignac 1954). Moir (1967) reported similar findings for Kentucky bluegrass on fine-textured soils in southern New Mexico.

Forbs such as common dandelion, Fremont geranium, and aspen fleabane frequently become more abundant with grazing, and sometimes replace the secondary grasses. More commonly, however, these plants, along with mountain brome, slender wheatgrass, Letterman needlegrass, western yarrow, orange sneezeweed, aspen peavine, and herbaceous cinquefoils occur in various mixtures (Klemmedson 1956; Paulsen 1969, 1970a). Big sagebrush and Parry rabbitbrush tend to increase with overgrazing on some sites.

In Wyoming, Idaho fescue and other common components of relatively undisturbed grasslands, such as thickspike wheatgrass, slender wheatgrass, bluebunch wheatgrass, pumpelly brome, inland bluegrass, pale agoseris, and silky lupine, become less prominent under grazing pressure. Tending to replace them are needleleaf sedge, prairie Junegrass, big bluegrass, Canby bluegrass, Cusick bluegrass, Sandberg bluegrass, subalpine needlegrass, avens, starry cerastium, and western yarrow (Hurd 1961, Williams 1963).

On mountain range near Bozeman, Montana (Branson and Lommasson 1958), where improved management included lighter grazing, percentages of herbage yields contributed by individual species changed noticeably. This range, which varied in elevation from 6,100 to 7,500 feet, formerly had been overgrazed by sheep and cattle. From 1932 to 1955, grass yields increased from 32 to 47 percent of the total herbage, while forb yields decreased from 68 to 52 percent. Prominent species that increased were mountain brome (*Bromus marginatus* in list of plant names), timothy, and Kentucky bluegrass; those that decreased were slender wheatgrass, Idaho fescue, starry cerastium, sticky geranium, and cinquefoil. Certain species apparently respond differently to grazing or to release from grazing, depending upon local circumstances.

Range Condition

Range condition, defined as "the current productivity of a range relative to what that range is naturally capable of producing" (ASRM-Range Term Glossary Comm. 1974), commonly considers vegetation, litter, and surface soil (Hanson 1951, Parker 1951). Rangeland that is influenced little, if at all, by livestock provides the standard for classifying condition, which is ordinarily expressed in relative terms such as excellent, good, fair, or poor. Ratings are made through use of score cards developed for specific sites (Dyksterhuis 1949), or major plant communities (USDA-FS 1962). Different criteria are used for sheep range than for cattle range.

Range condition classification may not provide a reliable guide to grazing capacity, and may not necessarily indicate condition relative to the management goal. For example, dense stands of Thurber fescue produce much herbage and provide excellent watershed cover (Turner and Dortignac 1954), but often produce relatively less forage than associated grasses because of its coarseness. Certain forbs contribute appreciably to the quantity and quality of forage on these ranges (table 2) (Paulsen 1969). Pocket gophers also influence range condition of mountain grasslands (Moore and Reid 1951, Ellison and Aldous 1952, Turner 1969).

Table 2.--Production, cattle preference, and relative forage value for forage species on mountain grassland ranges, Black Mesa Experimental Forest and Range, Colorado (from Paulsen 1969)

Species	Production	Utilization by number of days grazed				Forage value[1]
		18	36	56	78	
	lb/acre	*Percent*				
GRASSES AND GRASSLIKE:						
Idaho fescue	222	5	8	15	38	1.00
Letterman needlegrass	126	3	4	8	32	.47
Thurber fescue	119	4	7	12	28	.39
Bromegrass	51	6	9	14	38	.24
Slender wheatgrass	55	7	12	15	36	.22
Kentucky bluegrass	7	13	10	31	46	.04
Others	55					
FORBS:						
Aspen fleabane	90	3	12	25		.26
Aspen peavine	65	3	6	10		.07
Agoseris	33	11	13	17		.07
False sunflower	9	9		44		.05
Goldenrod	11	1		18		.02
Dandelion	16	8	8	10		.02
Sharpleaf valerian	11	1	6	14		.02
Others	500					

[1]Ranking based upon the product of final utilization and production divided by the product obtained for Idaho fescue. Species listed were present on at least 5 percent of the plots.

Although the condition of mountain grassland can be evaluated on the basis of predetermined standards, trends in condition are much more difficult to determine. Vegetation and ground cover change in response to combined environmental influences, both seasonally and long-term. Most commonly considered in estimating trend are: (1) changes in relative abundance of plants preclassified according to their desirability or expected response to grazing; (2) plant vigor, usually expressed through number and height of grass flower stalks or length of leaves; and (3) soil stability, as evidenced by litter accumulation, surface runoff, and erosion (Parker 1951). Other factors sometimes considered are changes in size of grass clumps, abundance of seedlings or young plants, frequency of dead or dying plants, arrangement of plant colonies, amounts of forage produced, and current degree of grazing (Talbot 1937, Reid and Pickford 1946, Ellison 1951, Humphrey 1955). Under proper grazing with upward range trend, ground cover usually will reach or maintain a level sufficient

to prevent excessive erosion, soil nutrients will be recycled in amounts necessary to maintain soil fertility, and soil structure conducive to growth of forage plants will be maintained.

Long-term effects of grazing on chemical, microbiological, and physical characteristics of the soil are not well documented. Although most mountain grassland soils contain relatively large amounts of organic matter, the supply of available nutrients varies with soil acidity and parent material, abundance and activity of micro-organisms, and other factors (table 3). Soil structure normally is maintained by natural processes if the range is grazed when the ground surface is dry and firm. Organic matter tends to maintain a desirable soil structure by reducing or counteracting compaction (Lull 1959).

CURRENT RANGE USES AND RANCHING OPERATIONS

High-altitude rangelands are essential to the operation of many livestock ranches in the central Rockies, since their summer production rounds out the annual forage requirements. Hay grown under irrigation in the valleys provides winter feed for cattle; lower elevation rangelands, irrigated pastures, and crop aftermath may sustain the livestock during spring and fall months. Many sheep winter on semidesert shrub ranges, some of which are far from summer ranges. Sheep are commonly trucked from winter to spring range, and occasionally to summer range. If not, they are herded from range to range as the forage reaches a state of range readiness.

Mountain grasslands usually are grazed more heavily by cattle than are the interspersed aspen and shrub ranges. Sheep more commonly graze lands occupied by shrubs and trees, particularly within the aspen type. Few ranges are grazed by both sheep and cattle. Use of mountain grasslands by horses is expected to increase with increased use of the subalpine zone for recreational purposes.

In 1970, 2,763 permits were issued for grazing of summer range within National Forests of the Rocky Mountain Region. On an animal-unit basis, the cattle permitted outnumbered sheep about four to one.

Monetary value of forage supplied by mountain grasslands cannot be estimated accurately, partly because information is lacking on the extent of the grasslands and the values contributed by associated types that are grazed concurrently. Grazing values are indicated, however, by 1970 records that show that National Forest ranges in the Rocky Mountain Region (mainly Colorado and most of Wyoming) supplied forage for 1,110,627 animal-unit months (AUM)[3] of grazing from mid-June to mid-October. Computed at $3 per AUM, the annual grazing value exceeded $3 million. The livestock operations that utilize the high-altitude ranges are often the mainstay of the economy and welfare of local communities.

Higher costs inherent in management and improvement of range and livestock, including salaries for range riders, fencing, water development, noxious plant control, and range reseeding, however, substantially reduce the economic attractiveness of grazing mountain rangelands. Profits may be further reduced by relatively high losses of livestock grazing these remote ranges. For example, on National Forests of the Rocky Mountain Region, death losses from poisonous plants, predators, and other causes in 1970 amounted to 1.5 percent of the cattle and 3.8 percent of the sheep being grazed; monetary value of these animals probably exceeded $1 million.

[3]An animal-unit month is defined as the amount of feed or forage required by an animal unit (usually considered to be one mature cow with calf or their equivalent) for one month.

Table 3.--Analyses of the less than 2 mm fraction of soils from the Black Mesa Study Site[1] (from Paulsen 1970b)

Slope position and depth	Texture			Moisture-holding capacity		Organic matter	Lime	Nitrogen	pH	Phosphate (P_2O_5)	Potassium (K_2O)
	Sand	Silt	Clay	1/3 atm	15 atm						
	- - -	- - -	- - -	- - -	Percent	- - -	- - -	- - -		*lb/acre 6 inches*	
UPPER:											
0-12 inches	39	44	17	22	11	4.4	0.8	0.179	6.5	65	828
12-25 inches	43	40	17	19	9	1.5	.6	.073	6.5	44	620
> 25 inches	43	38	19	21	9	.8	.5	.043	6.2	61	490
LOWER:											
0-12 inches	39	44	17	22	12	5.3	.6	.210	6.2	52	798
12-25 inches	37	47	16	19	9	2.7	.6	.118	6.2	51	752
> 25 inches	51	35	14	17	8	1.0	.5	.052	6.2	42	540

[1]Analyses were completed by Cooperative Soils Laboratory, Colorado State University.

RANGE MANAGEMENT PRACTICES

Proper Grazing

Present knowledge is generally adequate for determining an acceptable level of grazing on mountain grasslands. Proper use from the standpoint of forage and livestock production basically aims to maintain or increase the productivity of grasslands through wise management. Concurrently, the condition and management of mountain grasslands influence the use of interspersed aspen and shrub ranges.

Among the factors that influence actual utilization of a plant species are its abundance, composition of associated vegetation, habits of the animals, stage of plant growth, climatic conditions, and management practices (Cassady 1941). Grazing of approximately 40 percent of the annual growth of palatable grasses by the end of the grazing period is generally recognized as not being detrimental to mountain grassland ranges that are in satisfactory condition.

Although Idaho fescue is a primary forage species on many mountain grassland ranges in Colorado and Wyoming, cattle use a number of other grasses and forbs; the latter are often grazed early in the grazing season (see table 2). Aspen fleabane, aspen peavine, and agoseris were among the more important forbs on Black Mesa in western Colorado (Paulsen 1969).

Shrubs seldom contribute appreciably to the diet of cattle on mountain grassland ranges. However, aspen root suckers are often browsed by livestock and big game. On Black Mesa, elk sedge ranked highest of the herbaceous species on aspen ranges intermingled with mountain grasslands (table 4).

Table 4.--Production, cattle preference, and relative forage value for forage species on aspen ranges, Black Mesa Experimental Forest and Range, Colorado (from Paulsen 1969)

Species	Production	Utilization by number of days grazed: 18	36	56	78	Forage value[1]
	lb/acre	*Percent*				
GRASSES AND GRASSLIKE:						
Elk sedge	205	2	5	8	9	1.00
Fringed brome	24	4	8	13	17	.22
Mountain brome	10	3	14		22	.11
Thurber fescue	24	3	12	18	7	.11
Slender wheatgrass	9	4	6	24	11	.06
Others	5					
FORBS:						
Meadowrue	44	1	6	15		.39
False sunflower	14	10	11	37		.28
Aspen peavine	59	2	3	7		.22
Fireweed	10	4	6	18		.11
Thistle	11	4	14	13		.06
Northern bedstraw	17	1	2	6		.06
Butterweed groundsel	21		1	5		.06
Others	279					

[1]Ranking based upon the product of final utilization and production divided by the product obtained for elk sedge. Species listed were present on at least 5 percent of the plots.

In the Big Horn Mountains of Wyoming, Idaho fescue furnished 75 percent of the cattle diet on grasslands underlain by soils of granitic origin (Pond and Smith 1971). On ranges underlain by sedimentary soils, a combination of Idaho fescue, big bluegrass, and wheatgrasses supplied 70 percent of the cattle diet; forbs made up only 10 percent. Silky lupine, though not the most palatable forb, provided most of the forb herbage consumed.

Sheep grazing Idaho fescue on the Big Horn Mountains preferred forbs over grasses (Pond and Smith 1971). Many of the more preferred species were not among the 10 most important plants in the animal diet, however (table 5). In western Colorado, important plants in the diet of sheep grazing on summer range were common dandelion, aspen fleabane, Porter ligusticum, purple meadowrue, and tall larkspur (Doran 1943). Less preferred species such as hairy goldaster, mountain thermopsis, and orange sneezeweed may be utilized 10 percent or less when more desirable species are present, but as much as 50 to 80 percent when desirable species are scarce (Cassady 1941). Some species are utilized to a greater extent when rare than when abundant; for example, silvery lupine, elephanthead pedicularis, and showy frasera. Certain species are preferred during short periods, while others are grazed throughout the grazing season; examples of the latter are common dandelion, western snowberry, and aspen peavine.

Table 5.--Rank of important forage plants in the diet and preference of sheep, Big Horn Mountains, Wyoming (May 1960)

Species	Basin sites: Sheep diet	Basin sites: Preference	Ridge sites: Sheep diet	Ridge sites: Preference
Silky lupine	1	6	6	3
Asters and fleabanes	2	3	3	5
Wheatgrasses	3	4		
Dunhead sedge	4	5		
Avens	5	10		
Pale agoseris	6	2		
Common dandelion	7	1		
Flowery phlox	8	7		
Sandberg bluegrass	9	8	5	4
Blueleaf cinquefoil	10	9		
Needleleaf and Hepburn sedges			1	2
Timber danthonia			2	6
Silky crazyweed			4	1
Idaho fescue			7	7

Kinds of Animals

Mountain grasslands are generally suitable for grazing by many kinds of herbivores. Cattle prefer areas with gentle terrain and a predominance of palatable grasses. Those with a more rugged terrain and vegetation rich in forbs and browse are more suitable for sheep. Elk obtain much of their summer food supply from grasslands, while deer depend mainly on forage from associated brushland and timber types. However, small grassland openings and borders of large grasslands are important habitat for deer, elk, and other wildlife.

Factors that influence or determine the kind of livestock with which a range is stocked include: (1) availability and distribution of water; (2) kind, extent, and distribution of vegetation types; (3) composition of herbaceous and shrubby vegetation; (4) range condition and management goal; (5) feasibility of livestock control; (6) economic considerations; (7) history, policy, and allocations of range use; (8) conflict with other uses or interests; and (9) personal preferences and desires of ranchers or livestock associations. Except for operational complications and economic considerations, alternate or dual use of the range by sheep and cattle may offer a feasible, biologically sound, and effective means for controlling composition of rangeland vegetation.

Number of Animals

Proper stocking of mountain grasslands varies with: (1) kind, age, and size of animal; (2) range condition; (3) management objectives; (4) amount and quality of usable forage; (5) system of grazing; (6) season of grazing; (7) length of grazing period; (8) kind, extent, and distribution of associated vegetation types; and (9) uniformity of livestock distribution. As on other types, a key indicator of proper stocking is the intensity of forage use. The range manager must recognize variation in forage production attributable to weather, and avoid use that over the long term would result in range deterioration.

Under continuous, seasonlong use, the grazing capacity of mountain grassland range in good condition is about 1.5 acres per AUM (USDA-FS 1962). It may be somewhat higher under ideal conditions and much lower under less favorable conditions. About 2.5 acres per AUM may be a reasonable overall estimate for the type. Yearlings require two-thirds to three-fourths as much forage as fully grown cattle.

If the management objective is to achieve relatively light use and high individual weight gains, stocking should be relatively light. If closer use of the range is permissible and individual weight gains are less important, stocking can be heavier. More live weight gain per acre results from the latter, unless the range is stocked too heavily. Use of the more productive and palatable grasses, such as Idaho fescue, should not exceed 40 to 45 percent on properly stocked range grazed seasonlong (Beetle and others 1961). Whether mountain grasslands can be stocked more heavily for short or intermittent periods without causing damage to the range has not been determined.

To utilize palatable and nutritive forbs more fully, stocking may be somewhat heavier during the forepart of the grazing season than in the fall when many plants have dried and shriveled. Grass use tends to increase as forbs become less readily available (Paulsen 1969).

Season of Grazing

Guidelines for range readiness are generally similar though more conservative than those developed 50 years ago by Jardine and Anderson (1919). Guides for cattle ranges usually stipulate that important perennial grasses be headed out, and that the soil be sufficiently firm to avoid trampling damage by livestock. On sheep range, flowering of principal forbs may be the basic criterion. Dates of snow disappearance and other weather characteristics generally indicate when those stages may be attained (Costello and Price 1939).

Closing of the grazing season usually is dictated by weather and/or quantity and quality of remaining forage. The grazing season for sheep ordinarily is shorter than that for cattle because most sheep range is at higher elevations where plants develop later and much of the forage is damaged or destroyed by frost early in the fall.

From investigations of seasonal trends in carbohydrate reserves, McCarty and Price (1942) concluded that grazing of plants during their reproductive period is especially harmful. Because early grazing is limited by wetness of soil and scarcity of forage, and late grazing by reduced palatability of most plants, poor-quality forage, and adverse weather conditions, they decided that moderate use was the key to management of rangelands supporting mountain brome and slender wheatgrass. They suggested that grazing be intermittent, rotated, or slackened periodically to allow for seed production and range seeding.

The summer forage supply is both larger and more nutritious than that available early in spring or late in fall. Most grass and sedge herbage appears to be nutritionally deficient after late August. Chemical analyses of forage collected on Black Mesa at specific phenological stages are shown in table 6.

Through the first half of the grazing period on Black Mesa, three forbs that furnished appreciable amounts of forage were nutritionally superior to the grasses. Even after the forbs were dry and decumbent, they showed crude protein, phosphorus, and calcium levels above the minimum nutrient requirements prescribed for maintaining normal growth of 600-pound steers or heifers (Natl. Res. Counc. 1963). Analyses of forage species of the Big Horn Mountains, Wyoming, showed similar nutritional values and seasonal trends (Pond and Smith 1971).

Grazing Systems

The basic purpose of a grazing system is to insure that plant and soil resources continue to be productive. Selection and adoption of any system will depend upon the kind of vegetation, the physiography of the range, the kind of animals, and the objectives of the manager (Stoddart and others 1975). Regardless of the system used, one of the most difficult jobs

Table 6.--Percentage crude protein, phosphorus, and calcium of major forage species, 1962-63, Black Mesa Experimental Forest and Range, Colorado (from Paulsen 1969)

Nutrient and species	Phenological development			
	Leaves only	Flower-ing	Seed ripening and dispersal	Regrowth; dormancy
CRUDE PROTEIN:				
Idaho fescue		9.8	9.0	7.0
Thurber fescue		9.8	8.6	6.1
Letterman needlegrass		11.8	9.6	7.0
Slender wheatgrass		9.5	11.9	5.5
Bromegrass		11.4	11.4	7.1
Elk sedge				10.2
Aspen fleabane	18.1	14.8	12.0	11.0
Agoseris		15.1	11.6	11.2
Aspen peavine		21.7	21.5	17.8
PHOSPHORUS:				
Idaho fescue		.21	.15	.12
Thurber fescue		.19	.14	.12
Letterman needlegrass		.18	.14	.09
Slender wheatgrass		.20	.28	.11
Bromegrass		.24	.36	.13
Elk sedge				.18
Aspen fleabane	.40	.31	.21	.24
Agoseris		.38	.36	.34
Aspen peavine		.23	.22	.18
CALCIUM:				
Idaho fescue		.56	.62	.55
Thurber fescue		.36	.39	.31
Letterman needlegrass		.56	.52	.46
Slender wheatgrass		.44	.45	.47
Bromegrass		.58	.54	.57
Elk sedge				.58
Aspen fleabane	1.46	1.31	1.74	1.74
Agoseris		1.94	2.04	2.84
Aspen peavine		1.66	1.78	2.29

in range management is to obtain uniform utilization of the forage resource (Driscoll 1967). Common range management practices such as salting, supplying water, installing fences, and riding or herding complement each other in overcoming many grazing distribution problems.

Continuous grazing has been practiced on mountain grassland ranges for many years. Much too frequently it has been employed with too many livestock over too long a season. Undesirable successional changes in plant cover have resulted where animals grazed available forage from time of snowmelt until snow or cold weather forced them to lower elevations. Continuous grazing, however, does not mean simply closing the gate and letting livestock graze at will without attention to proven principles of range management. Continuous grazing can achieve any desired degree of use. It has often been judged successful on moderately stocked ranges where other management practices have been added to achieve desired goals. The system is best adapted to small range units in relatively good condition and on which livestock distribution is not a problem. Cattle need not adjust to abrupt changes in forage supply, and animal weight gains are commonly higher than under other systems. In comparison to other systems, continuous grazing requires the least investment for range improvements, minimum handling and movement of livestock and, generally, use of different classes of forage when they are most nutritious. However, disadvantages of continuous grazing cited by Driscoll (1967) are:

1. Animals tend to concentrate in the same places at the same time year after year.
2. Forage is often wasted because of poor distribution of livestock and its uneven utilization.
3. Even if the range unit is "properly" grazed, the better forage plants where livestock prefer to graze are overutilized and may be eliminated.

Early-day range managers of mountain grassland ranges perceived a need and advocated various grazing systems to improve range condition and obtain more uniform use of the range (Sampson 1913, Douglas 1915). With development and refinement of scientific principles of range management, numerous grazing systems have evolved that help meet the growth and reproductive requirements of the more important forage plants and maintain the range in relatively productive condition. Common terms which describe these systems include the following:

Deferred—a unit is not grazed until after seed maturity.
Rest—a unit is not grazed in a given year.
Rotation—units are grazed on a scheduled basis.

Various combinations of these terms are used to describe specific grazing plans, such as deferred-rotation or rest-rotation. Within this framework, plans may be developed that are contingent upon the number of herds, number of animals in each herd, number of range units or pastures, size of pastures, and dates or plant phenological stages when animals are to be moved (Heady 1975). They require that the range be divided into two or more units. The four most common systems have been described by Driscoll (1967): rotation or alternate grazing, deferred grazing, deferred-rotation grazing, and rest-rotation grazing. The number of units in these systems depends on the intensity of management and physical characteristics of the land. Fencing or careful herding, together with judiciously placed salt and water, usually are required to effectively control livestock distribution.

On many summer ranges, about one-third of the grazing season remains after seed maturity; on those ranges, at least three subunits are required. The unit or allotment should be subdivided so that all subunits have similar grazing capacities.

Cost of improvements needed to control livestock is the major deterrent to the adoption of specialized grazing systems. Fencing of mountainous rangeland is expensive, and economic considerations may preclude intensive management of many areas. Sheep

ranges, of course, need not be fenced if sheep are controlled by herding. Subdividing the range into units suitable for refined grazing systems may be constrained by differences in elevation and plant development, natural barriers, unequal distribution of vegetation types, and other factors that prevent an individual unit from supplying its share of forage when needed (Stoddart and Smith 1955).

Development and distribution of water are usually costly, and may pose difficult problems in implementing deferred or rotation systems of grazing.

Although the expense of adopting specialized systems of grazing may not always be justified, experience has shown that range conditions usually improve under such management (Driscoll 1967). In a Wyoming study, either rotation or rest-rotation systems were found to benefit mountain ranges grazed by cattle (Johnson 1965). The most striking result was a reduction in utilization without a reduction in the number of animals grazing the areas. These systems are beneficial if the physiological needs of the vegetation are effectively met through proper planning and execution. However, on the Bighorn National Forest in Wyoming, a 7-year comparison of range conditions and cattle weight gains did not prove conclusively that rotation grazing in itself was better than seasonlong grazing (Pond and Smith 1971).

Decision as to the best system for grazing individual ranges must be based on local conditions and circumstances. Although various modifications of these grazing systems are now in operation on many mountainous rangelands, most have not been sufficiently evaluated.

A spinoff benefit that has been realized from adoption of some intensified system of grazing is the increased attention given to other facets of range management. For example, range seeding and noxious plant control are frequently included with fencing and water development in the overall management plan. Such range improvement practices may be integrated without fencing for grazing control into a management plan that incorporates rest in the grazing system.

Improving Forage Production

Seeding

Seeding of mountain grasslands may be needed and justified if satisfactory range condition cannot be restored within a reasonable time through grazing management or control of undesirable plants. Extreme scarcity of desirable plants, regardless of ground cover density, is one of the more obvious and reliable indicators of the need to reseed. Suitability of the site for seeding, need for additional forage, ability to protect and manage the seeded area, and costs and returns from seeding should be considered. An estimated 5 percent of the spruce-fir zone in Colorado is in need of seeding. Many of the better sites can be seeded on the basis of available guidelines (Stewart and others 1939, Doran 1951, Hull and others 1958, McGinnies and others 1963).

Although climate of the subalpine zone generally is conducive to successful seeding, failures may result from inadequate precipitation during the growing season or frost heaving during winter. Chances for successful seeding could be improved, however, with better understanding of the influence of weather on seedling development. Failures may occur if seedbed preparation is inadequate or seeded stands are improperly managed. Practical and generally effective methods for seeding unfavorable sites, such as those with shallow, rocky soils, or those inaccessible to equipment for preparing the seedbed, have not been developed.

Species adapted to mountain grasslands are numerous. However, adapted legumes are generally needed to increase nitrogen content of the soil. Also, palatable and nutritious seeded grasses sometimes would be useful in providing forage earlier in the season than do native species.

Management of seeded ranges must be predicated on basic principles of good range management. Published guidelines (Stewart and others 1939, Doran 1951, Hull and others 1958) point out practices that will prevent depletion of seedings: (1) protecting seeded areas from grazing until plants are well established; (2) grazing at the proper season and intensity, commonly in separate units; (3) fertilizing high producing stands; (4) occasional mowing at the end of the grazing period to clean up the coarse, ungrazed plants; and (5) providing for flexibility in stocking to accommodate variation in herbage yields. Insofar as is known, no controlled experiments have been conducted to determine and compare responses of seeded ranges in the subalpine zone to different systems of grazing.

Costs of seeding and related improvements needed for management of seeded areas vary widely. Conditions under which seeding of mountain grasslands is economically feasible have not been adequately determined. Return from the investment varies, of course, not only with fixed costs but with initial success of and subsequent production from the seeding.

Noxious Plant and Animal Control

Noxious or undesirable plants have been controlled mainly with chemical herbicides. Mechanical methods, except possibly for control of tall larkspur and big sagebrush, have generally been ineffective, impractical, or uneconomic. Biological methods have received little attention and, as far is known, are not available for or applicable to noxious plants on mountain grasslands.

Herbicides can effectively control many range plants, both desirable and undesirable. Numerous kinds have been developed, and the more common ones, especially 2,4-D and 2,4,5-T, have been widely used for many years. Basic principles of herbicide use are reasonably well known (Romancier 1965, Freed and Morris 1967), and guidelines for controlling several plant species on mountain grasslands are available (U.S. Range Seeding Equip. Comm. 1966). Use of herbicides has been directed mainly at controlling individual forb or shrub species considered to be undesirable. Such practice frequently has resulted in increased grass production and improved range condition where grasses were relatively abundant prior to treatment.

Some target plants survive herbicide applications because of differences in phenological development, genetic composition, a supply of viable seeds in the soil, or resistance to certain kinds or concentrations of herbicides (Roché 1971). Such plants may become more prominent following treatment and, if undesirable, may intensify the problem of plant control (McKell and Chilcote 1957).

Parry rabbitbrush and Fremont geranium, prevalent species on some mountain grasslands, are resistant to commonly used herbicides, and satisfactory methods for their control have not been developed. Tordon offers promise but is expensive (Paulsen and Miller 1968). Control of certain poisonous plants, such as the low larkspurs, also has been ineffective or impractical on mountain grasslands.

On rangelands sprayed with herbicide, livestock are usually removed for 1 to 3 years to obtain the greatest possible benefit from spraying. Smith's (1969a) results indicate that satisfactory improvement may be obtained under moderate grazing without deferment. Future use of herbicides for increasing the forage supply may hinge on their overall effects on the environment.

Where pocket gophers are abundant enough to consume or destroy a sizable part of the mountain grassland forage crop, they have been effectively controlled by killing with herbicide most of the forbs on which they rely for food (Hansen and Ward 1966). Because of restricted use of the known effective pesticides, a practical method for controlling gophers over extensive areas is not available.

Rodents other than pocket gophers, particularly montane voles and deer mice, are relatively common on mountain grasslands and when abundant they too may appreciably reduce the forage supply. Voles compete directly with livestock for forage, and deer mice influence the amount and availability of plant seed. In general, deer mice tend to be more abundant on rangeland with sparse cover, and voles on ranges with relatively dense cover (Tester and Marshall 1961). Suitability of the habitat for these rodents evidently can be influenced appreciably through intensity of grazing by livestock.

Insects, such as grasshoppers, occasionally destroy much rangeland forage. Their control also was severely hampered when certain insecticides were restricted or banned.

Dual use of summer range by livestock and big game may occasionally result in overuse and decline in forage production. Big game often move on to mountain grassland ranges as soon as the areas are free of snow. Where animals are concentrated, damage to the soil and forage resource may result. To achieve proper and balanced use under such conditions, adjustments in animal numbers and reallocation of rangeland to accommodate the needs of both may be necessary.

Fertilizing the Range

Grass yields, crude protein content, and palatability of mountain grassland vegetation may be increased under certain conditions by fertilizing the range with nitrogen (Smith and Lang 1962). Over a 5-year period in the Big Horn Mountains, Wyoming, significant increases in grass forage were obtained on a fine gravelly loam soil. With optimum application rate (50 pounds of available N per acre) the additional yield was estimated at 150 pounds of ovendry forage per acre. Maximum grass response was obtained when fertilization was combined with control of broad-leaved plants. However, the increase in each case did not approach what was considered economic feasibility. Under other experiments, little if any vegetation improvement was obtained from the application of nitrogen, phosphorus, potassium, sulfur, and several minor elements (Hull 1963).

Possibilities for changing composition of grassland vegetation through use of different kinds and amounts of fertilizer are evident from tests on mountain meadows (Cooper and Sawyer 1955). Nitrogen generally favors growth of grasses, while phosphorus and potassium encourage growth of legumes. On experimental plots on Black Mesa (Paulsen 1970b), applications of 350 pounds per acre of nitrogen from ammonium sulfate and 300 pounds per acre of phosphorus in superphosphate for 3 successive years significantly reduced the cover of Thurber fescue by the third year. The effect was also apparent on aspen fleabane and cinquefoil, two prominent forbs on the plots. Although Fremont geranium was the most abundant forb, fertilizer treatment had no effect on this species' cover.

As pointed out by Retzer (1954), plants will respond to fertilizer when the fertility status of a soil is low or unbalanced, but they will not respond when the fertility status is high and well balanced. Tests usually are needed to determine the status of soil nutrients. Ample rainfall and soil moisture are required for the vegetation to effectively use the fertil-

izer. On relatively infertile soils, best results may be achieved by fertilizing in conjunction with the control of noxious plants.

Water Spreading

Water spreading is seldom practiced on mountain grasslands. Its potential for appreciably increasing forage production is small, mainly because conditions rarely are suitable for adequate control of water on mountainous rangeland. On relatively flat terrain, water spreading may increase both quantity and quality of forage available as well as provide an effective means for controlling big sagebrush.

Contour trenching with other improvement practices such as seeding and grazing control have been successful on high range watersheds in the West. On moderately steep slopes, specialized equipment has been developed that can remove soil from a trench and move it downslope into a ridge while operating at a reasonably rapid speed (U.S. Range Seeding Equip. Comm. 1965).

Controlled Burning

Little is known about how fire influences productivity or floristic composition of mountain grasslands. Findings from various sources, as summarized by Wright (1971), indicate that fire will stimulate forage production in stagnated grassland communities. He concluded that "Huge buildups of litter lower soil temperatures which in turn reduce bacterial activity, tie up nutrients, and slow the general nitrogen cycling process, particularly during cool, wet years. In dry years, litter is important for insulation, protection from flash floods, and in general plants grow better if they are not burned."

Dead organic matter in relatively dense, lightly grazed stands of Thurber fescue may weigh more than 5 tons per acre (Turner and Dortignac 1954). Under such conditions burning may increase the quantity or improve the quality of forage. Where ground cover is sparse, or the range closely grazed, burning may be detrimental or infeasible. Under some conditions, controlled burning may influence not only the forage supply for livestock, but the kinds and abundance of wildlife (Miller 1963). Montane voles, for example, possibly could be reduced or controlled through prescribed burning since they tend to become more abundant with increased litter. Deer mice have become more abundant following fire (Wright 1971).

Prescribed burning also offers a potential means for controlling grassland insects and diseases. Implications of indirect effects of fire on wildlife and forage production are obvious and far reaching, but there is little in the literature that is specific for Thurber fescue or Wyoming bunchgrass ranges.

On grasslands with sagebrush overstory, fire may kill shrubs and release understory grasses. However, rabbitbrush is not readily killed by fire and, where present, it may become more abundant. Idaho fescue evidently is more readily damaged or destroyed by fire than are associated plants of bluebunch wheatgrass (Conrad and Poulton 1966). These findings indicate that fire may play an important role in determining composition of grassland vegetation. By deterring encroachment of trees into grassland openings, fire tends to maintain the grassland openings.

Increasing Range Usability

Practices to improve cattle distribution and thus increase usability of mountain rangelands, as summarized by Skovlin (1965), are generally applicable to mountain grasslands of the central Rockies. Briefly, they are as follows:

1. Develop water supplies on ungrazed areas to reduce grazing pressure near existing water.

2. Fence to limit use to the best season and to control grazing between range types.

3. Add salt grounds to lightly grazed areas at locations that will encourage greater use.

4. Redistribute cattle through range riding, moving them from heavily grazed range to lightly grazed or ungrazed range.

5. Construct trails or driftways to improve access to isolated tracts.

6. Manage native forage through manipulation of the plant cover.

Relatively uniform use of sheep range can be achieved by conscientious herding. Maximum usability of cattle range, however, can be attained by applying several complementary practices. For each range or range unit, practices must be tailored to fit local conditions. A basic question is whether such practices, or which practices, are actually needed or economically justified. The basic tools with which to obtain uniform use of the range are available.

Cost data for range improvement practices on mountain grassland ranges were summarized from Duran and Kaiser (1972) (table 7). Since their values were averages, other data may vary from those presented. Costs of range improvements commonly are shared by the rancher and Government when livestock are grazed on Federally owned land and the practices are considered mutually beneficial.

Table 7.--Costs and life expectancy for range improvement practices on mountain grassland ranges (from Ouran and Kaiser 1972)

Practice and costs	High-production sites	Low-production sites	Life expectancy
			Years
PER ACRE:			
Seeding	$ 5.50	$ 8.50	30
Noxious plant control	5.00	5.50	15
Rodent control	3.50	3.50	30
Insect and disease control	1.50	1.50	20
Fertilization	15.00	15.00	2
Water spreading[1]	7.00	8.00	30
Controlled burning	3.00	3.00	5
PER MILE:			
Fencing	1,500.00	2,200.00	25
EACH:			
Water developments	350.00	600.00	30

[1]Authors include practices such as sprinklers and ditches to provide water to areas deficient in moisture.

Managing the Livestock

Many animals are grass-fat when removed from mountain grassland range. Forage nutrient changes are reflected in animal weight gains however, which almost invariably decline with advance of the season (Pond and Smith 1971). Yearling cattle on Black Mesa showed an average gain of 1.5 pounds per head per day from approximately September 1 until October 1. The gain from mid-July until September 1 averaged 2.4 pounds per head per day, or about 62 percent more than late in the season. In the Big Horn Mountains of northern Wyoming, the average daily gain per steer was 1.89, 2.22, and 2.41 pounds for heavy, moderate, and light forage use, respectively (Beetle and others 1961). Livestock may occasionally lose weight during periods of inclement weather or inadequate forage supply. Though economically important in the production of grass-fat animals for market, such loss may not be detrimental to maintenance of the breeding herd.

By fall, crude protein and phosphorus content of the more common grasses may approach minimum levels recommended for maintenance of cows and calves, especially when rainfall is deficient (Paulsen 1969, Pond and Smith 1971). Calcium content of forage evidently remains sufficiently high throughout the summer. Although mineralized salt commonly is provided, the need for it in addition to common salt has not been established. Nutrient deficiencies on summer ranges usually are not serious, and supplements seldom are fed there. Open-grown forage tends to have a higher carbohydrate content than that grown in shade (Watkins 1940). Fragmentary records indicate that weight gains of cattle on grassland are higher than on cattle confined to aspen groves.

Death losses from low larkspur, a serious problem on some mountain grassland ranges, may be avoided by withholding cattle from the range until most of the plants have dried up. Losses from tall larkspur may be reduced by fencing out highly infested areas or control of individual plants. Relatively few cattle are lost to predators.

Traditionally, a good herder has been considered the key to good management of sheep on mountain grassland/aspen range. Limited comparisons indicate, however, that sheep may not need to be herded on fenced mountain rangeland. Such practice resulted in satisfactory use of the forage resource in Wyoming (Jones and Paddock 1966). Former losses of sheep on range infested with orange sneezeweed have been greatly reduced by improved management practices such as open herding where there is an ample supply of palatable forage, avoidance of sneezeweed areas, and general improvement of range condition. Losses of sheep to predators are often high, and possibly will increase with increasing restrictions on predator control. Relationships between predators and sheep losses are being further investigated.

LIVESTOCK GRAZING AND OTHER USES

Water and Timber Production

Good range management usually is considered good watershed management, particularly in regard to maintaining soil stability; properly managed grazing animals seldom are detrimental to watersheds in satisfactory condition. However, Gary (1975) concluded that while good range management and revegetation will improve watershed conditions, such measures do not assure that intense runoff will not occur during severe storms.

Most mountain grasslands in the central Rockies support a denser cover and are less subject to erosion than those at lower elevation. From plot tests on numerous grassland sites in western Colorado, Turner and Dortignac (1954) found that infiltration rates were relatively high, and erosion rates were low, under most conditions. Infiltration rates were lowest on sites dominated by Kentucky bluegrass. Erosion rates were high where ground cover was sparse and much bare soil was exposed.

On Black Mesa watersheds, Frank and others (1975) found no significant change in runoff or sediment production attributable to various intensities of cattle grazing. According to their records, 99 percent of total yearly runoff and 89 percent of suspended sediment were produced during spring snowmelt. Sediment yields were small, and apparently came from a few local areas such as stream channels and other sites with little protective cover. Soil recently deposited on the ground surface by pocket gophers probably contributed to sediment movement.

Leaf (1975) concluded that moderate intensities of cattle grazing do not affect water runoff on watersheds with extensive grassland parks.

Water use by mountain grassland and adjacent spruce-fir and aspen types was compared on Black Mesa (Brown and Thompson 1965). Soils sampled gravimetrically to an 8-foot depth showed average total water use in inches per day for three summer growing seasons of 0.165 for aspen, 0.132 for spruce-fir, and 0.079 for grassland.

Little is known about water yields from mountain grasslands, although estimates approximating those characterizing adjacent forest types may be appropriate (Ffolliott and Thorud 1974). Livestock trampling tends to compact the soil and increase surface runoff. The extent to which grazing affects the yields of usable water from high-elevation rangelands by reducing transpiration or increasing evaporation is not known.

Contamination of domestic water supplies by livestock has received little attention. In general, concentrations of all chemical water-quality components in subalpine streams are low (Leaf 1975). Bacterial counts vary widely, but a strong positive bacteria-to-flow relationship can be expected. High concentrations associated with grazing and recreation appear to result from the "flushing effect" of runoff from snowmelt and summer storms. In some areas, siltation resulting from range use by livestock has made streams unsuitable for fish. Browsing of streamside willows and other shrubs also has generally degraded fish habitat by increasing exposure to sunlight and raising water temperature.

Browsing and trampling occasionally damage or destroy coniferous tree seedlings and saplings adjacent to mountain grassland openings within the forest. If such damage is detrimental, fencing of forest plantations or removal of livestock may be required to prevent damage to young trees. However, on properly stocked rangeland, conflicts involving damage to natural regeneration of timber and livestock production seldom are serious.

Aspen stands intermingled with mountain grasslands, however, are more apt to suffer animal damage. Browsing of aspen root suckers by livestock and big game may be sufficiently severe to curtail its sprouting capability. Stripping of aspen bark by elk and rodents exposes the trees to disease and reduces esthetic value of the stands.

Improper grazing by cattle may result in increased abundance of forbs that serve as alternate hosts for timber-damaging fungi. Chickweed is an alternate host for *Melampsorella caryophyllacearum*, the causal agent of fir broom rust (Peterson 1964). Comandra is the alternate host for *Cronartium comandrae*, which causes widespread mortality of lodgepole pine (Tackle 1959). Laycock and Krebill (1967) reported that, although comandra is not readily eaten by cattle, it could increase on overgrazed range when selective grazing pressure causes the more palatable species to decrease; the evidence, however, is conflicting.

Wildlife and Recreation

Mountain grasslands provide much forage for game and nongame animals in the central Rockies. Although the habitat of most animals in the subalpine zone is an admixture of vegetation types, grasslands are an important part of the complex.

Estimated numbers of big game within and harvested from National Forests in Colorado and Wyoming in 1972 were as follows:

	Number present	Number harvested
Pronghorn	14,000	3,000
Whitetail deer	2,000	184
Mule deer	296,000	36,000
Elk	102,000	18,000
Moose	820	85
Mountain goat	450	5
Bighorn sheep	5,100	95
Black bear	6,500	380
Grizzly bear	110	1
Turkey	6,000	256

During part of the year most of these species make some use of mountain grasslands in conjunction with adjacent forest.

Openings created by logging of the coniferous forest often furnish temporary forage for livestock and wildlife until tree reproduction again occupies the site. Forage species are often the same as those of intermingled mountain grasslands. Total forage production usually begins to decline after 10 years, and new openings should be cut about every 20 years to maintain this source of forage.

In comparisons of the use made by cattle, elk, and deer of natural and created openings (logged areas) in spruce-fir forests in Arizona, Reynolds (1966) found that cattle preferred the natural openings whereas deer and elk preferred the created openings. In Wyoming, however, Ward and others (1973) reported similar grazing patterns and area preferences for elk and cattle, which were often observed within 200 yards of each other.

In Arizona, elk and deer preferred created openings; however, openings larger than 20 acres were little used by game except near the forest borders. Wallmo (1969) reported that alternating cut and uncut strips 3 chains wide attracted the most deer use. Size of the natural openings was not a factor in influencing cattle grazing. Increased amounts of variety of high-quality forage are the obvious attractions in openings.

Although the above studies indicate the impact of timber harvesting practices on wildlife, information on the size, shape, and arrangement of cutover units

or the periodicity of cutting required to maintain desired habitat conditions needs to be refined. These data are needed to provide the numerical input for mathematical models of timber–wildlife interactions. Additionally, not enough information is available on nongame animals or their habitat requirements to adequately assess the impact of timber harvesting practices.

Visitor-days' use of National Forests and Grasslands in the Rocky Mountain Region by hunters and fishermen during 1971 were estimated to be 1,422,000 days spent fishing, 876,000 days hunting for big game, and 57,000 days hunting for small game animals. Production, use, and enjoyment of wildlife doubtless are influenced appreciably by the manner and degree to which mountain grasslands are grazed by livestock.

To some people, the presence of livestock on the range adds to scenic interest and attractiveness. To others, livestock are a nuisance, especially around campgrounds. Tourists occasionally disturb livestock, and visitor activities may reduce the amount of rangeland suitable for grazing. In general, conflicts between grazing and recreation do not appear to be serious or widespread, but problems may develop locally as recreation demands increase.

The preceding discussion centered on how livestock grazing affects associated resource values of the subalpine region. Because of the overriding influence of the forest overstory, the impact of various timber cutting practices on these products and values should also be considered.

Various systems of cutting the overstory have been evaluated on a 0-5 scale (fig. 6). The ratings of wildlife habitat, livestock forage, and water yield are relatively high for the clearcutting and group-selection harvest systems, somewhat lower for the shelterwood system, followed by the selection system, with the effect of no cutting rated lowest. In contrast, the rating of the esthetic appeal of the forest stand improved as more of the stand was left undisturbed. Refinement and quantification of the ratings are needed to improve understanding of the interactions between the products and values.

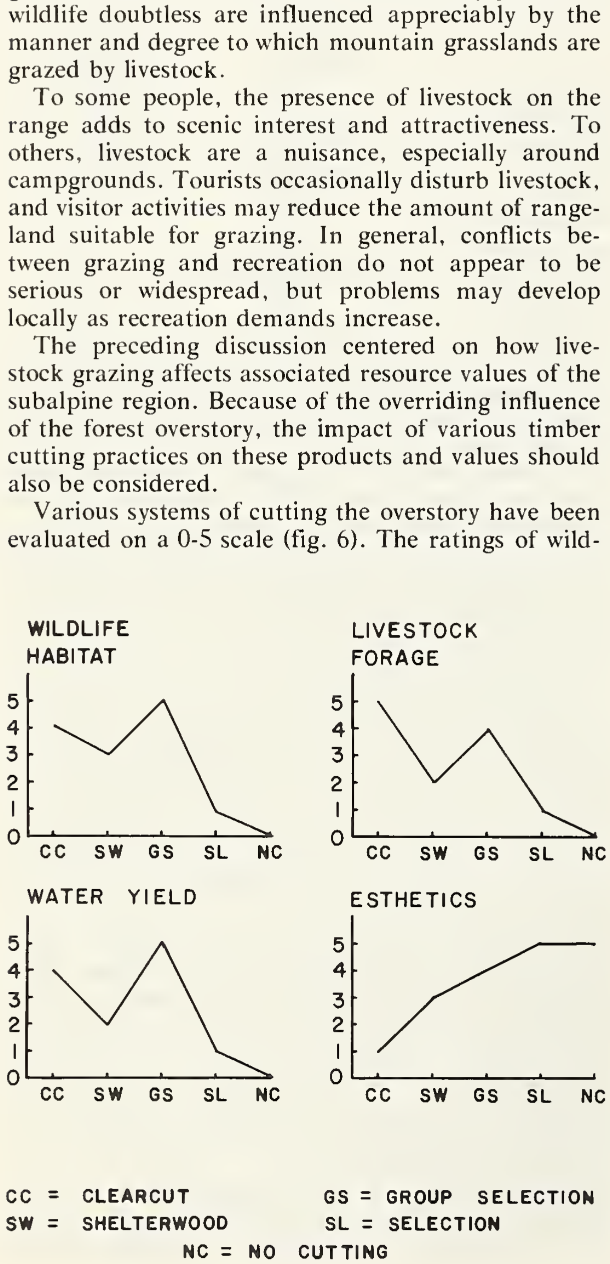

Figure 6.—Relationship of four resources in the subalpine forest zone to different cutting systems on a 0 to 5 rating scale.

EMERGING DEMANDS FOR MOUNTAIN GRASSLAND RESOURCES

Mountain grasslands of the central Rockies are an integral part of the subalpine zone, which is a major source of water for millions of people as far away as California and Mexico. The area's outstanding beauty and its developing yearlong recreational opportunities are attracting increasing numbers of people nationwide, and forcing change upon the more traditional uses of the zone. Nevertheless, mountain grassland and associated ranges are locally important. Ranchers, dependent on these ranges for summer grazing, contribute much to the economy of small communities. Some foresee continued or increased demand for mountain rangelands to maintain beef breeding herds as part of an integrated and more efficient livestock industry (Hodgson and Hodgson 1971). Others believe that future production of range livestock will shift to highly productive range and pasture lands in the South and East (Blaisdell and others 1970).

In view of (1) the increasing demand for beef, (2) the need to limit the amount of flammable vegetation on grazable areas, (3) the likelihood that grazing is not detrimental to maintenance of high yields of usable water, and (4) the importance of ranching to the welfare of local communities, continued grazing of mountain grasslands appears feasible and desirable. There is no doubt, however, that demands for mountain grasslands for various purposes will increase, and that local adjustments will be needed to accommodate those uses and demands. To do so adequately will require more intensive application of known range management principles and practices, as well as the development of new knowledge and tools that will enhance the land managers' capabilities.

LAND MANAGEMENT PROBLEMS AND RESEARCH NEEDS

Knowledge is generally adequate for extensive management of mountain grasslands in the central Rockies. Unfortunately, not all the knowledge necessary for efficient management is readily accessible to the manager. Furthermore, since grazing management is being complicated by increasing demands for rangeland uses, the contemporary range manager must increasingly direct his efforts to multiple use management in its broadest sense. Bases for this management must be developed through research to determine how various land management practices influence the productivity and quality of all resources, the complex processes and interactions involved, and tradeoffs among various uses and products. The manager also will have to take advantage of modern and developing technologies such as remote sensing, other refined measurement techniques, computer-assisted data handling, and evaluations of complex socioeconomic factors.

Nonetheless, the need persists for additional sound resource data that can provide a better basis for achieving the goals of more intensive range management. Urgent needs relative to management of mountain grasslands are improved guidelines for estimating site capability, and increased knowledge of the autecology of important plant components and their responses to grazing. Development of criteria for classifying mountain grasslands according to their potential, as has been done for other range types (Renner and Allred 1962), would be an important step in that direction. Additional perplexing aspects of range management that confront the manager and for which specific research information is inadequate already have been mentioned. The most significant ones are:

- Identification, description, and correlation of mountain grassland soils.

- Causes of annual variations in grass:forb herbage production.

- Factors controlling production of viable seeds of major forage species.

- Influence of fire, erosion, phytotoxins, and soil nutrients on mountain grassland succession.

- The role of biological agents and physical factors of the environment in fostering or limiting changes in mountain grassland communities.

- Long-term effects of grazing on soil productivity, the disposition of ungrazed plant residues, and amounts of residues needed to maintain soil organic matter.

- Specific effects of heavy stocking for short periods on vegetation and soils.

- Methods for seeding unfavorable sites, and improved understanding of the needs for seedling growth and establishment.

- Effects on the ecosystem of manipulating individual biological components.

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COMMON AND SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED OR FOUND IN THE MOUNTAIN GRASSLANDS

Grasses and Grasslike

Bluegrass, big	*Poa ampla* Merr.
Bluegrass, Canby	*Poa canbyi* (Scribn.) Piper
Bluegrass, Cusick	*Poa cusickii* Vasey
Bluegrass, inland	*Poa interior* Rydb.
Bluegrass, Kentucky	*Poa pratensis* L.
Bluegrass, mutton	*Poa fendleriana* (Steud.) Vasey
Bluegrass, Sandberg	*Poa secunda* Presl.
Brome, fringed	*Bromus ciliatus* L.
Brome, mountain	*Bromus marginatus* Nees. *Bromus carinatus* Hook. & Arn.
Brome, pumpelly	*Bromus pumpellianus* Scribn.
Bromegrass	*Bromus anomalus* Rupr.
Danthonia, timber	*Danthonia intermedia* Vasey
Fescue, Idaho	*Festuca idahoensis* Elmer
Fescue, Thurber	*Festuca thurberi* Vasey
Hairgrass, tufted	*Deschampsia caespitosa* (L.) Beauv.
Junegrass, prairie	*Koeleria cristata* (L.) Pers.
Needlegrass	*Stipa* spp.
Needlegrass, letterman	*Stipa lettermani* Vasey
Needlegrass, subalpine	*Stipa columbiana* Macoun
Sedge	*Carex* spp.
Sedge, dunhead	*Carex phaeocephala* Piper
Sedge, elk	*Carex geyeri* Boott.
Sedge, Hepburn	*Carex hepburnii* Boott.
Sedge, needleleaf	*Carex obtusata* Lilj.
Spikefescue	*Hesperochloa kingii* (S. Wats.) Rydb.
Timothy	*Phleum pratense* L.
Timothy, alpine	*Phleum alpinum* L.
Wheatgrass	*Agropyron* spp.
Wheatgrass, bluebunch	*Agropyron spicatum* (Pursh) Scribn. & Smith
Wheatgrass, slender	*Agropyron trachycaulum* (Link) Malte
Wheatgrass, thickspike	*Agropyron dasystachyum* (Hook.) Scribn.
Wheatgrass, western	*Agropyron smithii* Rydb.

Forbs

Agoseris	*Agoseris* spp.
Agoseris, pale	*Agoseris glauca* (Pursh) D. Dietr.
Aster	*Aster* spp.
Avens	*Geum ciliatum* Pursh
Beauty, spring	*Claytonia lanceolata* Pursh
Bedstraw, northern	*Galium boreale* L.
Bluebell, greenleaf	*Mertensia viridus* A. Nels.
Cerastium, starry	*Cerastium arvense* L.
Chickweed	*Stellaria media* (L.) Cyrill.
Cinquefoil	*Potentilla* spp.
Cinquefoil, blueleaf	*Potentilla glaucophylla* Lehm.
Cinquefoil, Nuttall	*Potentilla nuttallii* Lehm.
Comandra	*Comandra* spp.
Crazyweed, silky	*Oxytropis sericea* Nutt.
Dandelion, common	*Taraxacum officinale* Wiggars
Fireweed	*Epilobium angustifolium* L.
Fleabane	*Erigeron* spp.
Fleabane, aspen	*Erigeron speciosus* (Lindl.) DC
Frasera, showy	*Frasera speciosa* Griseb.
Geranium, Fremont	*Geranium fremontii* Torr. ex Gray
Geranium sticky	*Geranium viscosissimum* F. and M.
Goldaster, hairy	*Chrysopsis villosa* (Pursh) Nutt. ex DC.
Goldenrod	*Solidago* spp.
Groundsel, butterweed	*Senecio serra* Hook.
Jasmine, rock	*Androsace septentrionalis* L.
Larkspur	*Delphinium* spp.
Larkspur, duncecap	*Delphinium occidentale* (Wats.) Wats.
Larkspur, low	*Delphinium nelsonii* Greene
Larkspur, tall	*Delphinium barbeyi* (Huth.) Huth.
Ligusticum, Porter	*Ligusticum porteri* Coult. & Rose
Lily, fawn	*Erythronium grandiflorum* Pursh
Lupine, silky	*Lupinus sericeus* Pursh
Lupine, silvery	*Lupinus argenteus* Pursh
Meadowrue, purple	*Thalictrum dasycarpum* Fisch. & Lall. ex. Fisch., May & Lall.
Mulesear	*Wyethia* spp.
Peavine, aspen	*Lathyrus leucanthus* Rydb.
Pedicularis, elephanthead	*Pedicularis groenlandica* Retz.
Phlox, flowery	*Phlox multiflora* A. Nels.
Sneezeweed, orange	*Helenium hoopesii* A. Gray
Sunflower, false	*Helianthella quinquenervis* (Hook.) A. Gray
Thermopsis, mountain	*Thermopsis montana* Nutt. ex. T. & G.
Thistle	*Cirsium centaureae* (Rydb.) K. Schum.
Trumpet, Gabriel's	*Gilia aggregata* (Pursh) Spreng.
Valerian, sharpleaf	*Valeriana acutiloba* (Rydb.) F. G. Meyer
Yarrow, western	*Achillea lanulosa* Nutt.

Trees and Shrubs

Aspen, quaking	*Populus tremuloides* Michx.
Fir, subalpine	*Abies lasiocarpa* (Hook.) Nutt.
Oak, Gambel	*Quercus gambellii* Nutt.
Pine, lodgepole	*Pinus contorta* Dougl.
Pine, ponderosa	*Pinus ponderosa* Laws.
Rabbitbrush	*Chrysothamnus* spp.
Rabbitbrush, Parry	*Chrysothamnus parryi* (A. Gray) Greene
Sagebrush	*Artemisia* spp.
Sagebrush, big	*Artemisia tridentata* Nutt.
Sagebrush, silver	*Artemisia cana* Pursh
Snowberry, western	*Symphoricarpos occidentalis* Hook.
Spruce, Engelmann	*Picea engelmannii* Parry
Willow	*Salix* spp.

Mammals

Badger	*Taxidea taxus* (Schreber)
Bat, hoary	*Lasiurus cinereus* (Palisot de Beauvois)
Bat, little brown	*Myotis lucifugus* (Le Conte)
Bat, silver-haired	*Lasionycteris noctivagans* (Le Conte)
Bear, black	*Ursus americanus* Pallas
Bear, grizzly	*Ursus arctos* Linnaeus
Beaver	*Castor canadensis* Kuhl
Bobcat	*Lynx rufus* (Schreber)
Chipmunk, least	*Eutamias minimus* (Bachman)
Cottontail, mountain	*Sylvilagus nuttallii* (Bachman)
Coyote	*Canis latrans* Say
Deer, mule	*Odocoileus hemionus* (Rafinesque)
Deer, whitetail	*Odocoileus virginianus* (Zimmerman)
Elk	*Cervus elaphus* Eryteben
Fox, red	*Vulpes vulpes* (Linnaeus)
Goat, mountain	*Oreamnus americanus* (De Blainville)
Gopher, northern pocket	*Thomomys talpoides* (Richardson)
Jackrabbit, white-tailed	*Lepus townsendii* Bachman
Lion, mountain	*Felis concolor* Linnaeus
Marmot, yellow-bellied	*Marmota flaviventris* (Audubon and Bachman)
Marten	*Martes americana* (Turton)
Moose	*Alces alces* (Linnaeus)
Mouse, deer	*Peromyscus maniculatus* (Wagner)
Mouse, western jumping	*Zapus princeps* Allens
Pika	*Ochotona princeps* (Richardson)
Porcupine	*Erethizon dorsatum* (Linnaeus)
Pronghorn (antelope)	*Antilocapra americana* (Ord)
Sheep, bighorn	*Ovis canadensis* Shaw
Shrew, masked	*Sorex cinereus* Kerr
Shrew, vagrant	*Sorex vagrans* Baird
Skunk, striped	*Mephitis mephitis* (Schreber)
Squirrel, golden-mantled ground	*Spermophilus lateralis* (Say)
Vole, montane	*Microtus montanus* (Peale)
Weasel, long-tailed	*Mustela frenata* Lichtenstein
Woodrat, bushy-tailed	*Neotoma cinerea* (Ord)

Birds

Chickadee, mountain	*Parus gambeli* Ridgeway
Dipper	*Cinclus mexicanus* Swainson
Eagle, golden	*Aquila chrysaetos* (Linnaeus)
Finch, Cassin's	*Carpodacus cassinii* Baird
Flicker, common	*Colaptes auratus* (Linnaeus)
Flycatcher, Hammond's	*Empidonax hammondii* (Xantus)
Flycatcher, olive-sided	*Nuttallornis borealis* (Swainson)
Grosbeak, pine	*Pinicola enucleator* (Linnaeus)
Grouse, blue	*Dendragapus obscurus* (Say)
Hawk, red-tailed	*Buteo jamaicensis* (Gmelin)
Hummingbird, broad-tailed	*Selasphorus platycercus* (Swainson)
Jay, gray	*Perisoreus canadensis* (Linnaeus)
Jay, Steller's	*Cyanocitta stelleri* (Gmelin)
Junco, gray-headed	*Junco caniceps* (Woodhouse)
Kinglet, golden-crowned	*Regulus satrapa* Lichtenstein
Kinglet, ruby-crowned	*Regulus calendula* (Linnaeus)
Nutcracker, Clark's	*Nucifraga columbiana* (Wilson)
Nuthatch, red-breasted	*Sitta canadensis* Linnaeus
Owl, great horned	*Bubo virginianus* (Gmelin)
Pewee, western wood	*Contopus sordidulus* Sclater
Raven, common	*Corvus corax* Linnaeus
Robin, American	*Turdus migratorius* Linnaeus
Sapsucker, yellow-bellied	*Sphyrapicus varius* (Linnaeus)
Sapsucker, Williamson's	*Sphyrapicus thyroideus* (Cassin)
Siskin, pine	*Spinus pinus* (Wilson)
Sparrow, Lincoln's	*Melospiza lincolnii* (Audubon)
Sparrow, white-crowned	*Zonotrichia leucophrys* (Forster)
Swallow, violet-green	*Tachycineta thalassina* (Swainson)
Thrush, hermit	*Catharus guttatus* (Pallas)
Turkey	*Meleagris gallopavo* (Linnaeus)
Warbler, yellow-rumped	*Dendroica coronata* (Linnaeus)
Woodpecker, northern three-toed	*Picoides tridactylus* (Linnaeus)
Wren, house	*Troglodytes aldon* Vieillot

Reptiles and Amphibians

Snakes, garter	*Thamnophis* spp. Fitzinger
Salamander, tiger	*Ambystoma tigrinum* (Green)
Toad, western	*Bufo boreas* Baird and Girard
Frog, leopard	*Rana pipiens* Schreber

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Keywords: Range management, mountain grasslands, subalpine forest ranges.

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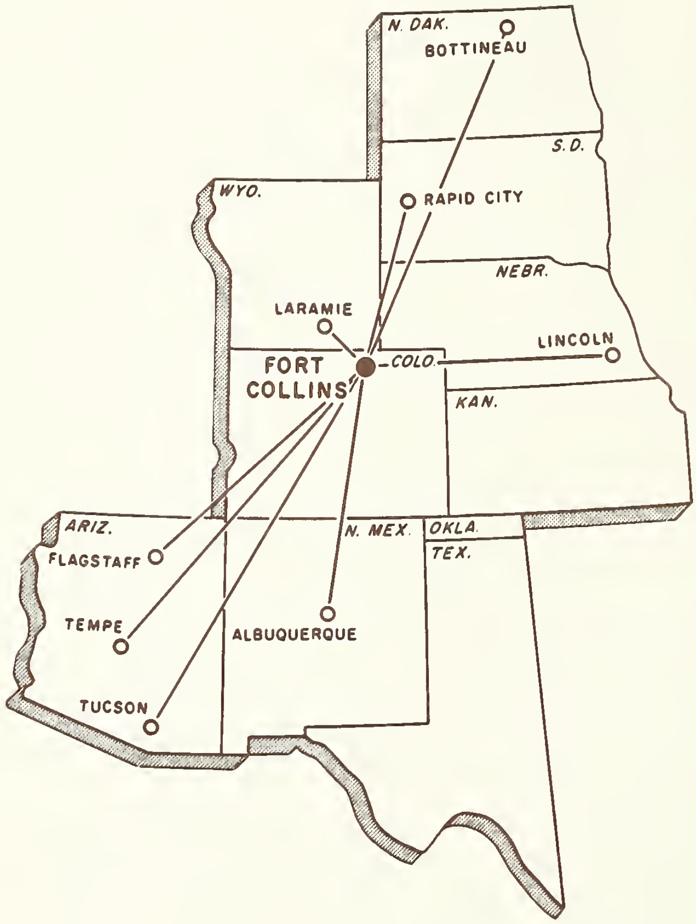
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